

Coral reefs and the slow emergence of institutional structures for a glocal land- and sea-based collective dilemma

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ABSTRACT

Coral reefs are subject to multiple stressors. Global stressors include climate change and ocean acidification, while local stressors include overfishing and eutrophication. Some stressors stem from land-based activities, like intensive agriculture or sewage production, while others are sea-based, like fishing or diving. Processes that aim to tackle coral degradation are transpiring on different levels. These include the UNDP's Sustainable Development Goal 14, and the Coral Triangle Initiative, which foresees the installation of marine protected areas and conservation planning. This paper uses Evolutionary Governance Theory (EGT) to understand the current processes of changes in governance influencing coral reef health. EGT sees the change of governance as an evolutionary process. It emphasises that discourses play a crucial role in understanding governance evolution. Power, in particular power-knowledge in the Foucaultian sense, plays a crucial role as a driving factor. Governance does not change in a vacuum, but according to EGT is shaped by path, inter- and goal dependencies. Of late, the role of materiality - ecological and technological conditions - has been stressed as an important driver of governance change. The paper considers the main threats to corals identified in the literature and analyses how those factors mentioned by EGT help us to understand the observed governance changes. The case of coral reefs was chosen as it represents an example of extremely diverse processes of institutional changes. Therefore, it is well suited to learn if EGT helps in understanding governance changes observed in the marine sector.

1. Introduction: problem statement

Credible research predicts that in 2030, which will be a milestone in gauging our success in reaching the UNDP's Sustainable Development Goals, 60% of the world's coral reefs will be lost if a conservative business as usual scenario continues [1]. Today, 75% of the world's coral reefs are already rated as threatened, having undergone a substantial increase in stress in recent years [2]. Coral reefs are very important for humankind. While estimating the value of coral reefs is a difficult undertaking [3], the production of fish biomass, the recreational/tourism value, and coastal protection are the most obvious ecosystem service values produced by coral reefs [4]. Indeed, they are considered the most valuable marine ecosystem per area on the planet [5], and are estimated to support the livelihood of 500 million people [6]. Teh et al. [7] estimate that there are 6 million coral reef fishers, providing protein for many people, and it is suggested that nearly 30 million of the world's poorest people depend entirely on reefs for food [6]. If one further considers any as yet unknown services that might arise from coral reefs, such as the provision of bioactive compounds, or the intrinsic value of the reefs, it behoves action to slow the fast decline

of coral reef systems. Some studies stress that climate change leading to temperature rise and ocean acidification is already enough of a stressor for corals [1]. Temperature rise leads to coral bleaching events, which are occurring more frequently [8]. Only very healthy coral reefs can recover from these events, and only if they do not occur as frequently as predicted. Acidification leads to increased difficulties of the organisms to calcify [9].

Other studies emphasise local causes of reef decline [10]. As this study is particularly interested in land-sea interaction,¹ this issue bifurcates into land- and sea-based threats. In their global assessment of coral reefs, "Reefs at Risk Revisited", Burke et al. [2] distinguish between two kinds of land-based threats. First, there is coastal development, including coastal engineering, land-filling, runoff from coastal construction, sewage discharge and impacts from unsustainable tourism. In light of the urbanisation rate and the pressure on coastlines worldwide, these threats are of great importance. Second, they focus on watershed-based pollution, like erosion and nutrient fertilizer runoff from intensive agriculture or land use changes in general. One sea-based stressor is marine-based pollution resulting from activities like gas and oil extraction, aquaculture production, and shipping, which

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results in the release of ballast water, anchoring in coral reefs (particularly important for the tourism industry) or simply ship groundings. The second sea-based factor is overfishing or destructive fishing. Overfishing disrupts the critical ecological functions fish provide to coral reefs and can easily lead to a complete shift in habitat composition. Destructive fishing leads directly to the physical destruction of the reef.

Virtually all factors stressing reefs can be traced back to human action. From this perspective, it seems reasonable that certain actors, who might either profit directly from coral reefs or think it is an important asset, are pushing to change governance and ultimately human behaviour. With the grim predictions about coral reef health, the required change is immense. To a certain degree, stress from one factor can be counterbalanced by reducing another stressor [11]. On the other hand, management actions aiming to reduce one stressor might lead to an increase of another stressor [12]. There is interdependence between the various stressors and changes in stressors. Reasonable conservation planning requires knowledge of the relative damage of a particular stressor in comparison to another. One should also have an understanding of the difficulty and expense required to implement governance changes [13]. Considering the various factors pointed out by Burke et al., it becomes clear that many different levels of governance, various jurisdictions, and many different sectors of society and economy all have an important role to play in the emerging change in governance. Often, actors might not be aware that they are contributing to coral destruction (e.g., by flying), and the governance arena that needs to be addressed is not related to corals or even marine issues (e.g., emission trading). The governance of coral reefs is a problem of collective action. Most studies focusing on collective action problems in relation to the environment have either focused on local resources [14] or have analysed global collective dilemmas [15,16]. The governance of coral reefs is a fascinating multifaceted global (globally and locally intertwined) collective dilemma, which seems to require a particularly broad approach that builds on various theoretical building blocks like Evolutionary Governance Theory (EGT).

This study uses the lens of EGT to understand changes in governance contributing to coral reef health. It is structured as follows: First, the analytical framework provided by EGT is explicated in section two. Section three then follows the framework to describe governance changes that are strongly influencing the health of coral reefs. It is organised following the well-established structure of stressors provided by Burke et al. [2]. Where possible, it draws on examples of evolving governance from own research (aquaculture, MPA development and fishing). In other instances, the section draws on general literature. The basic aim of section three is to provide sufficient empirical material to discuss the suitability of an EGT lens for understanding the complexity of the coral reef dilemma.

2. Evolutionary Governance Theory: a framework in a nutshell

EGT has been described comprehensively in various other places [17–19]. The purposes of the following paragraphs are to reconsider the exceptional breadth of EGT, which is particularly suitable in the case of coral reef governance, and to emphasise some aspects of the theory that play a prominent role in understanding the multifaceted evolution of governance influencing coral reefs. Describing the multitude of stressors leading to the coral crisis emphasises the fact that governance in many different policy arenas, markets, communities etc. influences the state of corals. It also becomes apparent that changes in governance in many of those sectors might be necessary to solve the coral crisis. No single social or social-ecological theory can explain all the different processes taking place in these very different systems. EGT draws on many different theories and combines them in a single framework, leading to a concept that provides an explanation for a broad range of observed governance changes. The diverse set consists of biological theories of evolution, system theory, post-structuralism, institutional

and development economics [17].

At a first glance, this seems like a list of incompatible approaches, stemming from methodological holism and individualism [20]. However, one of the unifying aspects is the idea of seeing the change in governance as an **evolutionary process**. EGT does not view governance as a planned process, in which some governments set rules that are intended to improve resource use. Governance is not only determined by state actors, but also by civil society and private actors, whether these are large corporations or an individual fisher or fishmonger, have an important, but not deterministic influence on the emergence of rules for societal or economic interactions. “Variations in markets and democracies, and in their evolutions, have produced many different governance systems [21,22]” [17, p.5]. Governance evolves most often within a decentralised process, where many actors, either intentionally or unintentionally, shape new rules regarding what and for whom any action is permitted, obliged or forbidden [23].

Evolution of governance as an autopoietic process central in Luhmann's system theory is also inherent in post-structuralism **discourse** theory, in which narratives are recursively reproduced [17]. It also figures prominently in institutional economic theories, which have a strong root within evolutionary theory [24–26]. Institutional economics theory argues that discourses (mental models or ideology) are of particular importance to understanding governance change in processes characterised either by high uncertainty or in situations where institutional competition (e.g., via the market) is not as fierce, leaving little room for different interpretations [27–29].

The role of **power** is important in discourse theory. It has an important role to play in the constant negotiation and renegotiation of formal and informal institutions [17,43]. In this regard, power, knowledge and discourses are closely intertwined within discourse theory and EGT [30]. “It is a perspective on power that is inextricably coupled with knowledge, with power referring to many things, including the possibilities for actors or institutions to do things and gain certain effects. Power and knowledge are two mutually constituting elements of power/knowledge configurations” [31, p. 138]. Similarly, institutional theory emphasises the role of power for governance evolution, following a Weberian definition of power [32], using coercive means to force people into a particular governance regime. However, power might not only result from knowledge but also from better exit opportunities, higher ability to wait (think of a patron-client relationship in fisheries) [33,34], credibility, networks, sanctioning power, path dependencies, etc. [29].

Dependencies, a crucial concept within EGT, mainly building on institutional economic concepts [35], are another key explanatory factor in governance evolution. EGT distinguishes between path dependencies, interdependencies and goal dependencies [17]. Path dependencies explain the evolution of a governance system from its previous state. Once a particular path is chosen, e.g. a private property regime, it is more difficult to abandon this path and to move, for example, to a common property regime. A governance regime tends to stick to the same path. This might be, for example, due to high costs of changing a path, because it is difficult to change the majority of discourses, or because of a particular governance regime being part of an interdependent web of rules. This relates immediately to the second form of dependencies, which are interdependencies. Institutions as rules are interconnected. The change of one rule is only possible if many other rules change at the same time. This creates a stickiness of rules, which leads back to path dependencies. This stickiness is further increased due to actor interdependencies. A network of actors who depend and rely on each other makes a change more difficult if interdependent (and not unidirectional) dependencies exist. However, this links to the last dependency, which is the goal dependency. It is closely related to discourses. Governance change depends closely on a goal or vision that is shared by an important amount of actors. The Washington Consensus or the Sustainable Development Goals might provide examples for such goal dependencies. The discourses developing around

those very different goals had a strong influence on shaping governance evolution.

Environmental governance is influenced by the physical properties of the ecological system to be governed and the technological possibilities [36,37]. This influence of “**materiality**” has been discussed more recently within EGT [38]. In summary, an EGT lens on governance change related to corals should analyse the evolutionary nature of such processes, the importance of discourses and power/knowledge, the importance of dependencies, and the role of ecological and technological materiality.

3. Stressors, governance and theory

In the following section, the influencing factors derived from EGT in the last section are used to explore governance changes in relation to the various stressors coral reefs are exposed to. There is a multitude of governance realms that influence the health of coral reefs. One paper could not provide a comprehensive list. From this perspective, the paper aims to discuss at least one example for each stressor category provided by Burke et al. [2]. In the selection of the examples chosen, a “convenience sampling” approach is taken, as the purpose of this conceptual paper is not to allow for a rigorous testing of the usefulness of the EGT framework, but to elucidate and to discuss what an EGT lens can bring to an understanding of governance changes in the marine realm. The analytical framework and the empirical examples used are shown in Fig. 1.

3.1. Evolutionary governance for local stressors

3.1.1. Sea

Marine pollution stems from many factors, such as shipping, oil production, and marine **aquaculture** (mariculture). While one could look at any of those sectors, we use the example of aquaculture, a particularly fast growing sector, to analyse governance evolution in the field of marine pollution. The focus is on a case study on a quickly growing aquaculture sector in Bolinao, Philippines, which has a direct influence on the health of nearby coral reefs.² Aquaculture leads to the release of nutrients, either via the excrements of the fish or via excess feed. New bacteria or viruses may cause negative effects on the marine environment. From this perspective, rapidly expanding aquaculture facilities have a substantial and mostly negative influence on coral reefs.

Mariculture has grown rapidly in Bolinao and first developed in a process without any formal governance. Informal institutions evolved regarding contracts between cage owners and caretakers. Formal institutions lagged behind. It was quickly observed that arising environmental problems may cause harm to the owners of the cages and pens. Fish kills emerged. A clan owning many fish cages has been largely affected by it. The head of the clan was also the mayor of the municipality, which created the leadership necessary for collective action to happen [39]. As overexploitation of the resource base became too apparent, he implemented an institution (*path dependency*) that was formerly used in allocating fishing rights for regulating the amount of cages in the municipality. The fish kills cause financial duress for small cage owners. At the same time, supply chain integration took place, and large powerful owners provided a variety of services, including fingerlings, feed, harvesting and, most importantly, finances. A patron-client system emerged, where it seems obvious that the powerful actors having the assets had greater influence in shaping the rules. Positional

² The empirical data for this case is primary data which has been collected within the frame of the ACUTE Project. 70 in depth interviews have been made and participant observation was done within a period of eight months. Primary data was collected by Febrina Desrianti in close collaboration with the first author.

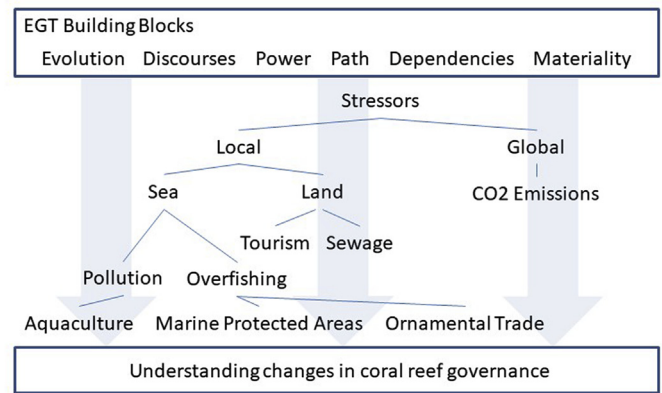


Fig. 1. Empirical framework to understand governance change for coral reefs.

power [33], rather than *discourses*, dominated the governance emergence. The ruling family has now shifted their economic interests toward the tourism sector, which might have positive implications for coral reefs.

The neighbouring municipality, Anda, does not have a powerful actor like the family clan in Bolinao to solve collective action problems. This municipality still has de facto no regulation on the number of pens and cages in the channel. The political “market” operating with widespread corruption does not allow the emergence of a rule that effectively regulates the amount of mariculture installations. From a holistic sustainability perspective, it is not clear which evolution of governance, in Bolinao or Anda, performs better.

Mariculture activity is particularly suitable for those two municipalities, as they are situated at a semi-closed channel that provides shelter and is regularly flushed. The flushing (*materiality*) is an important factor in limiting the size of the fish kills to a level that is manageable for the big producers. This might have prevented more rigorous institutional solutions.

Overfishing, the next important stressor, is governed at many levels, ranging from global and formal regulation to local informal regulation. To show the diversity of governance regimes and drivers, the paper briefly looks at marine protected areas (MPAs), with a focus on Costa Rica. Subsequently, the marine ornamental trade is explored, as it is a fishing activity with a particularly high potential for impacting the health of coral reefs.³

Governance using **MPAs** as a tool is emerging at all governance levels. On a global level, the Convention of Biological Diversity has set the goal to classify 10% of the marine space (within national jurisdiction) as protected by 2020 (CBD Target 11). In this policy field, it is clear that environmental *discourse* is competing with a resource utilisation and fishery perspective.

In Costa Rica, the emergence of MPAs was analysed in more detail [40,41]; this division is also well represented from the national to the local levels. These are two different traditions having different strategic positions, and being placed in two different government bodies that are often in conflict, namely the National System of Conservation Areas (SINAC) and the Costa Rican Fisheries and Aquaculture Institute (INCOFESCA). The conservation movement of Costa Rica is heavily

³ The insights on MPAs in Costa Rica are based on primary research done by Gabriela Morais in close collaboration with the first author. The research consisted of more than hundred semi structured interviews and participant observation during a period of 12 months [40] G. Weber de Morais, Governance of Marine Protected Areas in Costa Rica: stability and change of institutions, Shaker, Aachen, 2017. The primary data collection about the ornamental trade was done by the third author and consisted of a series of semi-structured and key informant interviews, focus group discussions, as well as a literature review and analysis of secondary data over a period of three years.

influenced by the conservationist movement of the US [42]. This division is present in many governments. The CBD resolution has promoted the expansions of national governance schemes regarding marine protection. However, many of them are so-called paper parks [43] that are subject to only superficial monitoring and enforcement. Costa Rica wanted to be the first country (in the global South) to achieve the protection of 10% of its marine territory [40, p.101].

A special tool for financing and determining marine governance to a certain degree was created. Costa Rica Por Siempre (Costa Rica Forever) is a private equity trust, mainly filled by a debt for nature swap. The founders are the Nature Conservancy, the Walton Family Foundation, the Gordon and Betty Moore Foundation and the Linden Trust for Conservation [44]. Costa Rica Por Siempre provides strongly needed funds for marine protection. However, it also influences marine governance of non-Costa Rican non-government organisations (NGOs). It is unclear whether this influence on governance is due to discourses or *power* stemming from financial resources.

Together with Conservation International, Costa Rica Por Siempre installed a radar system that allows control of small fishing boats entering MPAs. It is a system that works in combination with global monitoring systems based on GPS technology (AIS and WMS). This is a good example of how changed *materiality*, in this case the invention of a technology, plays an important role in institutional change, bringing *de jure* and *de facto* rights in marine governance closer together.

The local governance of the marine realm is strongly influenced by local situations and might not reflect formal governance, pointing to the importance of *path-* and *interdependencies*. The town of Ostional, where massive turtle arrivals occur, has gained a legally recognised right to extract turtle eggs based on historical claims and on proven scientific evidence that it is ecologically sustainable [45,46]. Cahuita, a small village in the Caribbean, has the informal right to levy an entrance fee on a donation basis for an MPA. This is a breach of the law, which has resulted in conflicts [40,47]. The worldwide *discourses* developing around the superiority of localised governance and participation has definitely helped those communities to get the *de facto* right to extract benefits of the marine resource. In both cases, the establishment of those weak local institutional equilibria was influenced by a strong distributional bargain (*power*) [48]. For the local communities, it is obvious that a huge degree of personal or local autonomy is at stake (the agreement in Ostional provides each participating family a monthly income of around 100 USD). For the government of Costa Rica, being a global leader in nature protection is at stake in the case of Ostional. For Cahuita, it is feared that a precedent for national and local benefit sharing has been created, which may reduce the flexibility of the national government.

Another important activity having potentially severe impacts on coral reefs is the *marine ornamental trade*. A particular focus is on research done in the Indonesian Spermonde Archipelago [49]. As 80% of the supply for the marine ornamental trade stems from Indonesia and the Philippines [50], the effect on corals is locally concentrated and significant. This market has grown substantially since the 1990s, presumably due to a change in aquarium technology that made it possible for Western consumers to keep ornamentals at home (*materiality*), coupled with the popularity of the film Finding Nemo [51,52]. Similar to aquaculture, the marine ornamental trade developed faster than the formal governance needed to manage it, which led to the emergence of spontaneous governance in local places (*evolution*).

In Spermonde, the aquarium fishery developed on the foundation of other fisheries and institutions already in place, showing a certain degree of *path dependency*. Compressors for dive fishing were already widespread as a result of sea cucumber and live reef fish fisheries expanding in the area a decade earlier, and many fishers simply added the collection of ornamental corals to their existing fishery portfolio [49]. The use of cyanide was already widespread among live reef fish collectors. Patron-client networks provided the links to international markets used later on by ornamental fishers [53]. The ornamental

fishery developed largely in response to trends in international markets, and institutional development in the marine ornamental trade accordingly evolved in response to the same drivers [49]. This shows the important role of markets and the role of (unregulated) competition. For reef fisheries in Spermonde, different institutions emerged depending on whether a target reef is in the proximity of inhabited or uninhabited islands [49]. For uninhabited islands, almost anything was possible. For inhabited islands, informal institutions often emerged, which regulated access and permitted gear use with reasonable success [54]. Ornamental trade in the Spermonde Archipelago is largely dominated by a complex system of patron and client relationships (*actor interdependencies*; for a more detailed description see [49]) The majority of fishers rely on patrons for fishing gear, such as boats and compressors, and over 90% depend on their patron for credit in times of need, leading to high rates of indebtedness.

Despite fishers knowing about the health risk of compressor diving, they largely accept it, and the associated risks are played down by the fishers, resolving cognitive dissonance with the help of a *discourse*. Patrons provide the necessary networks without which the fisher could not operate in the market. They provide the information on what is in high demand. They seem to be able to spread and dominate the discourse that scarcity is not a result of overfishing, but a result of natural fluctuations. Their salary is an order of magnitude higher than the income of their clients. This indicates that *power* – with a particular emphasis on market power – plays an important role in the informal institutions governing this business. In traditional patron-client relationships between small patrons and their fishers, who are operating in close social networks, the patron also plays an important role in reducing the vulnerability of the fishers. A tradition of institutions that obliges the patron to help out in case of urgency exists. At the time of this research, small patrons competed with each other to tie more fishers to them, as larger operations meant better opportunities when selling their products to patrons higher in the trade chain (wholesalers). This competition led to improvements of the contract conditions from the perspective of fishers [49].

3.1.2. Land

Growth and economic development is often strongest in coastal areas due to the myriad of livelihoods such regions support. In many coastal places, particularly where healthy coral reefs are nearby, the *tourism sector* is on the rise [55], creating challenges for local governance. Direct destruction by tourist boats anchoring in reefs and an increase in demand for high priced fish from coral reefs are among the effects of tourism. In concert with all other users of the coast, they produce sewage, which in many countries is *de facto* or even *de jure* unregulated. Increase in use brings symptoms of overuse to the shore, which induces pressure for changes in governance. Watershed-based pollution from the hinterland is another important stressor on coral reefs stemming from the land side.

The coast is characterised by a close proximity of many different social and social-ecological systems, which are characterised by strong *interdependencies*. This means that the governance of one system has considerable influence on the governance of the other sectors [56]. The amalgamation of so many actors, sectors, ecosystems, social systems (including markets as a sub-social system) and technologies require a broad theory or theories to understand the process of change of governance influencing coral reef health. In the tourism sector, for example, many different actors with strong *power differentials* interact [57]. A global hotel chain, for example, may operate in the same social system as a Nicaraguan who recently migrated to Costa Rica and runs rental cabins. Many of the emerging governance schemes depend on the particular sub-segment targeted (e.g., ecotourism) and how far this sub-segment can influence broader fields of governance [58]. Various emerging *discourses* (and their associated purchasing power) drive the development of governance [57]. Whether those discourses find their way into effective governance on the ground might be a question of

principal agent problems and monitoring costs. Any of those actors are exposed to tough economic competition: if the reefs are degraded, the price is too high, the fish are gone or the tourist ratings decrease, the flexibility in influencing governance goes down as well.

Sewage treatment, if there is any, is typically used by everybody jointly on the coast. Therefore, a very diverse set of actors in terms of their capabilities, interests, reliance on the system, their patience and their knowledge of how the system operates comes into play. The direct economic pressures and consequences of a particular governance of the sewage sector might not be as direct as for governance affecting only a single sector, such as tourism, or even a single product, such as dive tours. Sewage treatment is a significant infrastructure used by many, and therefore, deliberate decisions are more likely taken in a local political arena. Sewage gets to the sea, where it is diffused broadly, which means that effects and feedback on a particular governance regime are rather slow. Due to the long feedback loops, it takes time to learn what is reasonable from each actor's perspective [59]. Therefore, different understandings, mental models and developed *discourses* have a significant influence [28] next to the financial resources and technological and ecological possibilities involved. How high are infrastructural set-up costs and who finances them? Are there individual technological solutions, or is only a joint effort possible? Are the conditions of the estuary such that everything gets diluted right away, or does the sewage remain in the bay for a long time? All these factors indicate that *materiality* in conjunction with our understanding of it plays an important role in the evolution of governance in the coastal realm.

3.2. Evolutionary governance for global stressors

The calcification of corals and the bleaching events are, via acidification and temperature rise, two effects stemming from globally increased CO₂ content in the atmosphere. This is probably the most difficult governance issue existing, as it is a collective action problem encompassing the entire world population and is thus characterised by maximum heterogeneity. Heterogeneity can make collective action difficult [60]. Some participants contribute very little to CO₂ emissions, while others contribute a lot. Some have a substantial ability to contribute to a governance solution and its implementation, while others have no ability to contribute. Due to the complexity of this issue, there is, despite a strong consensus among scholars, still many pockets of scepticism among politicians and the general population as to whether the phenomenon of climate change is linked to emissions of CO₂ and other greenhouse gases. The consensus on the consequences for the various ecosystems, societies and economies is even further afield. Different *discourses* are competing.

High uncertainty and extremely complex feedback loops lead to the existence of many different positive mental models. Climate change and its governance have several distributive effects. Governance systems determine how the burden is shared [33]. Therefore, normative mental models and understandings of fairness play an important role.

On the global level, governance choices are made in the policy arena of global climate change negotiations. However, national policies then put the governance in place, aiming to achieve the established goals. There, the same mechanisms are at play. A strong belief in market mechanisms being able to solve the tragedy of the commons and allowing for efficient pollution control had a strong influence on creating the European Emission Trading Scheme in 2005. Environmental economists have worked on this narrative at least since 1960 [61]. Institutional *path dependencies* are also at play. Property rights development is necessary before being able to define CO₂ emission rights, a non-trivial governance issue. The experiences with Individual Tradable Quotas for fisheries, the first permit trading scheme developed, definitely left its footprint. Who is in and who is out of the scheme, and how the pollution permits are distributed, was determined to a certain degree by transaction costs, but probably more by a

Table 1

Relevance of theoretical concepts of EGT for provided cases.

Issue	Evolution	Discourse	Power	Dependencies	Materiality
Sea					
Aquaculture	X	X	XX	XXX	XX
MPAs	X	XXX	XX	XX	XX
Ornamental trade	XXX	X	XX	XX	X
Land					
Tourism	X	XX	XXX	XX	X
Sewage	X	XX	X	X	XX
Global					
CO ₂ Emissions	X	XXX	XX	X	X

distributive bargain between EU countries and sectors of the economy. *Power* resources in the hands of the actors played a crucial role. Through this strong determination of governance on the national level, institutional competition between states comes into play [62]. If one can opt out from climate agreements, those nations will be considered as free riders from the perspective of those who are still maintaining their commitments.

4. Discussion and conclusion: EGT and the evolution of governance affecting coral reefs

Considering the various stressors and the various levels and arenas where governance emerges, it is clear that many different forms of governance and many drivers influence the evolution of governance affecting the health of coral reefs. The relative importance of evolution, discourse, path dependencies, power, and materiality - factors focussed on in EGT - is impossible to determine in a precise and deterministic way. However, Table 1 synthesises the relative importance of each factor for the various governance realms considered. The relative importance (indicated by the number of X's) is derived from the importance in the various narratives above.

Considering the many influencing factors, it seems most appropriate to conceptualise change in marine governance as an **evolutionary** spontaneous process. It does not imply, as many evolutionary economics approaches assume, that mutation and selection would lead to an improvement of efficiency in economic terms [24,63,64]. Nor does it imply that "institutional entrepreneurs" do not aim to influence institutional change [65], sometimes reaching their goals, sometimes ending up with an unexpected outcome. Change in governance, understood as an evolutionary process, means that it is not deterministic, not easily predictable, and the result of complex interactions.

Discourses play an important role in the evolution of many governance processes. The roles of discourses and mental models increases the more uncertainty is involved in a process. If there is no broad consensus on how the system functions and what the implications of a governance change might be, the more important discourses will be for the evolution of governance [27]. This is particularly obvious when looking at the global level, where climate change deniers and scientists stressing the importance of behavioural change are pushing forward their distinct discourses. In many respects, the marine realm is less understood compared to land-based systems. Therefore, many uncertainties exist, and knowledge is in the hand of scientists who should (according to theory) have an important influence on discourses about governance change. On the other hand, the role of discourses varies according to the arenas where the governance change takes place. In the political arena (e.g., at the CBD or when a community decides on a sewage treatment plant), discourses might play a more important role than in markets where the communication mainly takes place via the price, such as in marine ornamental trade.

According to EGT "[p]ower is located in synchronic and diachronic relations; relations in networks of discourses and materialities, structures and elements, subjects and objects" [66, p. 14]. Therefore, power

can stem from many things. However, according to EGT, power and knowledge are intimately entwined: “power in all these forms can only be comprehended as interwoven with knowledge, as part of power/knowledge configurations” [66, p. 3]. Many of the examples listed above demonstrate that power stems from a broad variety of factors. Obviously, knowledge and information plays a role (see the role of patrons in marine ornamental trade). Other capabilities, any form of assets, market power and available alternatives might play a role, depending on the particular characteristic of the situation and existing power imbalances. From this perspective, evolutionary governance can be understood as a bargaining process in which, deliberately or not deliberately, actors compete for governance solutions, solving newly emerging problems or taking assumed opportunities [33].

Dependencies, in the form of path dependencies, interdependencies and goal dependencies emphasised by EGT [17], play an important role in the evolution of governance, which may be exemplified above with the relationship between Individual Tradable Quotas and emerging CO₂ trading schemes or with the relationship between small patrons and their clients. The marine realm is relatively less regulated than land. This also means that one would expect path dependencies to be more relevant on the land than on the seaside. As long as property rights (formal or informal) are not clearly defined, the flexibility of installing a governance system is still broader, as vested interests are less pronounced.

This smaller amount of governance in the marine realm is directly related to the last point raised, which is **materiality**: the technological and ecological conditions of a system. In many cases, one can see that they play a central role in understanding the evolution of the governance system. There is a wide variety of literature dealing with the institutional implications of the characteristics of social ecological systems [36,67]. EGT, with its focus on the evolution of governance, has more recently put its emphasis on aspects of materiality [38]. Social ecological system approaches demonstrate the direct role of materiality: The fact that ocean fish are highly mobile implies that, if not caged, one cannot have full ownership rights to them, but rights to appropriate a certain quantity [68]. EGT adds to this, arguing that materiality and discourses are intertwined, and the physical characteristics still allow for many different interpretations and resulting institutional solutions [38]: Individual Tradable Quotas are one of many forms of regulation, often preferred due to an economic discourse; a coral reef can, for example, primarily be seen by a society as a food source, a place of high biodiversity, needing protection, or a tourism asset, all influencing the evolution of governance.

Summing up, one can conclude that EGT provides a toolbox of very diverse and broad theories, which are able to help understanding the evolution of governance in relation to coral reefs. The marine realm, and here in particular coral reefs, are a new sphere, where knowledge is relatively scarce and uncertainty is high. This emphasises the role of discourse, a central concept in EGT. Some aspects, like fishing, have a rather long history of being governed. However, many aspects relating to the marine realm and corals, in particular, only began to be regulated more recently. From this perspective, one would argue path dependencies play a less prominent role. However, probably due to its materiality, e.g. the fluidity of the water, interdependencies, and here in particular actor interdependencies, play an important role [56,69]. When actors become important, power often obtains a central role, particularly in weak institutional systems. Considering the examples provided in the text, it becomes clear that important power resources move far beyond power related to knowledge. However, for example, the discourse on efficiency of fishing quotas by environmental economists, the discourse on the superiority of participation in planning processes of MPAs, or the battles on the global scene about climate change, show the important entanglement of power/knowledge and the particular role that scientists – might it be economists or climatologists – (still) play in it. The paper demonstrates clearly that EGT can grow and become a more universal framework beyond its application in the

marine realm. However, more important is that, conversely, the marine social science scholar can understand her subject far better by applying an EGT lens.

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